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(71) Applicant: FUJITSU LIMITED
Kawasaki-shi, Kanagawa 211 (JP)

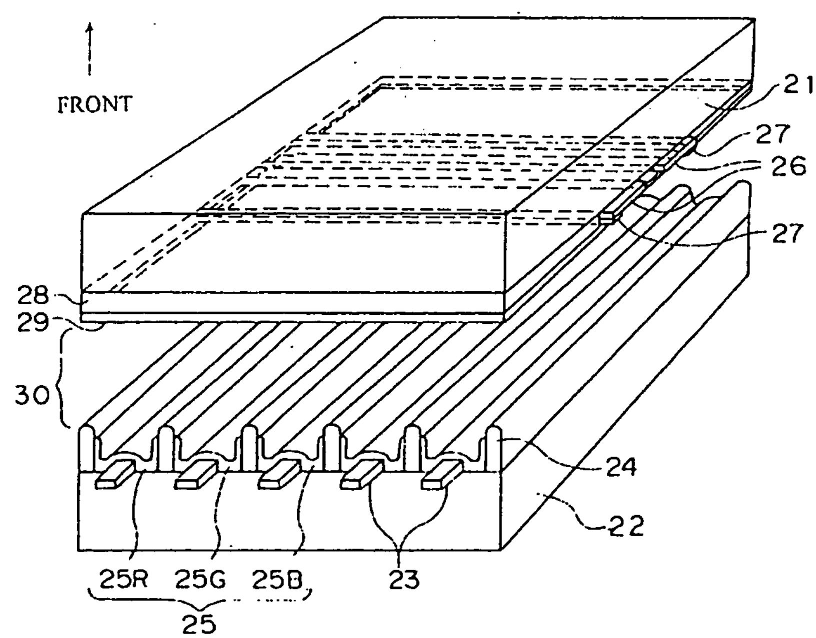
(72) Inventors:
- Hirota, Takatoshi
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Kimura, Hideo
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Imaoka, Kazuo
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Yokoyama, Satosi
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Sato, Mitsuharu
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Naoi, Shiro
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)
- Onoe, Takaaki
Nakahara-ku, Kawasaki-shi, Kanagawa 211 (JP)

(74) Representative: Godsill, John Kenneth et al
Haseltine Lake & Co.,
Imperial House,
15-19 Kingsway
London WC2B 6UD (GB)

(54) Flat display device

(57) In a flat display device having a pair of substrates (21, 22) for defining a gas discharge space (30) in which a gas used to generate discharge luminance is sealed, means (6 to 9) for absorbing or reflecting near infrared rays is included.

FIG.6



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Description

The present invention relates to a flat display device and, more particularly but not necessarily, to a flat display device used as an image display for use in computer, television and the like.

Plasma display panels, referred to as PDPs in the following, have been put to use in flat display devices such as wall hanging television sets. PDPs are classified into AC and DC types according to their voltage drive system. Generally, the display portion of an AC-type color PDP has the structure shown in Fig. 1 of the accompanying drawings.

As shown in Fig. 1, address electrodes 102 and a fluorescent layer covering the address electrodes 102 are formed on a glass substrate 101, designated the rear or back substrate in the following. A dielectric layer 105, a pair of display electrodes 106 and 107 and a protection layer 108 are formed on a further glass substrate 104, designated the front substrate in the following, which is arranged to face the rear glass substrate 101. Gas is sealed into a discharge space 109 formed between the front and rear glass substrates 104 and 101.

The operating lifetime, operating voltage, emission luminance, chromatic purity and so on are important performance criteria for such panels. These criteria are significantly affected by the gas mixture present in the discharge space 109.

Two different two-component gas mixtures have been contemplated, i.e. mixtures of neon (Ne) and xenon (Xe), and mixtures of helium (He) and xenon (Xe). Two three-component gas mixtures have also been contemplated, i.e. mixtures of helium, argon (Ar) and xenon, and mixtures of neon, argon and xenon.

It has been discovered by the present inventors that light having wavelengths outside the visible range, e.g. near infrared light, is generally emitted from PDPs using such gas mixtures.

The present inventors have also discovered that non-visible light emission, such as near infrared emission, can interfere with the transmission of infrared data transmission, which is used for example in point-of-sales (POS) computer information systems, such as bar code readers, and in remote controls used for controlling domestic electrical appliances. The use of a PDP as part of a POS system can thus cause interference with infrared signals used by other components of the POS system and the use of a PDP as a display for a home television set can cause interference with the remote control of that television set or of other appliances in the vicinity of the PDP. Malfunctions can thus ensue.

According to a first aspect of the invention, there is thus provided a flat display device adapted to cut off unnecessary light emission from its image display. Insodoing, it is not only possible to achieve a reduction in interference with other devices, for example by reducing near infrared emissions, but also to improve the image quality of the flat display device itself. For example chromatic purity and chromaticity can be enhanced by reducing the light intensity at the red end of the visible range.

According to a second aspect of the invention, there is provided a flat display device having means for reflecting or absorbing non-visible rays, whereby malfunction of devices operated by non-visible rays situated in the vicinity of the flat display device can be avoided. In a preferred embodiment, the reflecting/absorbing means reflects or absorbs near infrared rays, whereby malfunction of devices operated by near-infrared rays can be avoided.

According to a third aspect of the invention there is provided a flat display device having an optical film serving as an anti-reflection film with respect to visible wavelengths and serving as a reflection film with respect to near infrared wavelengths. Visible rays can thus be emitted from the flat display device to the outside with low losses from reflection and absorption in the flat display device. Deterioration in luminous display brightness of the flat display device can thus be reduced. At the same time emission of near-infrared rays can be suppressed.

According to a fourth aspect of the invention there is provided a flat display device comprising an electromagnetic wave shielding film and means for reflecting or absorbing near infrared rays. It is thus possible to suppress harmful influences upon a human body. The electromagnetic wave shielding film may be formed of a lamination film, or a growth film deposited for example by sputtering, CVD, evaporation and the like.

Furthermore, in a flat display device according to any of the above aspects of the invention, if a protection plate of glass, acrylic resin or plastics material is arranged in front of the substrates which define the discharge space, radiation of light having wavelengths shorter than that of visible rays can be suppressed and also the structure of the device can be strengthened. Moreover, the structural strength of the protection plate can be improved by providing a protection plate of convex shape and/or by fitting the protection plate into a frame.

In a preferred embodiment, the gas mixture in the gas discharge space includes xenon and neon, with xenon making up less than 2% of the total. The radiant quantity of light emitted from the flat display device in the wavelength range of 800 nm to 1200 nm can thus be reduced. Therefore, potentially harmful influences of the flat display panel upon any devices present in the vicinity of the flat display device that are operated by near infrared rays can be reduced or prevented.

Moreover, the image quality of the color display can be improved by providing means for manipulating the light intensity in the red region of the visible range at approximately 650 to 700 nm. In the flat display panel, since there is a possibility to increase the radiant quantity of the light around about 700 nm, the optical intensity at the wavelength can be reduced by providing means for absorbing or reflecting the light having the wavelength beyond 650 nm to thus

suppress deterioration in chromatic purity and chromaticity of color display.

In this event, if the display device is such that transmittance of the light having a wavelength below 650 nm is more than twice as high as transmittance of light having a wavelength of 700 nm, optical intensity at the wavelength can be reduced to thus suppress deterioration in chromatic purity and chromaticity of color display.

According to a fifth aspect of the invention, there is provided a flat display device having a gas mixture such that spectral intensity of infrared rays is less than the half the spectral intensity of visible rays in the gas discharge space of the flat display device.

Further aspects of the invention are exemplified by the attached claims.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is a sectional view showing an outline of a conventional plasma display;
Figs. 2a to 2c show the emission spectrum in the range 400 nm to 1200 nm for different mixture ratios of 0.2%, 2% and 3% of xenon;
Figs. 3a and 3b show the emission spectrum in the range 400 nm to 1200 nm for different mixture ratios of 4% and 5% of xenon;
Fig. 4 shows the relationship between the mixture ratio of xenon and the emitted spectral intensity around a wavelength of 880 nm;
Fig. 5 is a schematic view of the structure of a device according to an embodiment of the present invention;
Fig. 6 is a perspective view showing the inner structure of a display panel of the device shown in Fig. 5;
Fig. 7 is a sectional view showing an example of a convex protection plate;
Figs. 8a and 8b are front and side views showing an example of a protection plate with a frame;
Fig. 9 is a characteristic showing optical transmittance of an example of an optical filter to reflect specific wavelengths;
Fig. 10 is a view showing an example of characteristics of a visible-ray anti-reflection film;
Fig. 11 is a characteristic showing an example of the optical transmission characteristics of an infrared absorption filter;
Fig. 12 is a view showing the optical transmission when an optical filter and an infrared absorption filter are present;
Fig. 13 is a view showing an optical characteristic of an optical absorption filter or a reflection filter to cut off light within a specific wavelength band;
Fig. 14 is a view showing an optical characteristic of the optical absorption filter or the reflection filter to cut off light having specific wavelengths;
Fig. 15 is a view showing a characteristic of a first filter used to reduce transmission of light around the wavelength of 700 nm;
Fig. 16 is a view showing a characteristic of a second filter used to reduce transmission of light around the wavelength of 700 nm;
Fig. 17 is a view showing a characteristic of a third filter used to reduce transmission of light around the wavelength of 700 nm;
Fig. 18 is a view showing a characteristic of a fourth filter used to reduce transmission of light around the wavelength of 700 nm;
Fig. 19a is a schematic view of the structure of a device according to a second embodiment of the invention; and
Fig. 19b is an optical characteristic of a protection plate or a front transparent substrate used in the device of Fig. 19a.

In the following, the same or similar reference numerals are applied to the same or similar parts and elements. The description of the same or similar parts and elements may thus be omitted or simplified in the following to avoid duplication.

Figs. 2a to 2c and 3a to 3b show the emitted spectral intensity of a two component gas mixture in the wavelength range from 600 nm to 1200 nm for two different mixture ratios of Xe in a two component gas mixture of Ne and Xe, in a color PDP containing the gas mixture.

In Fig. 2a, in which the mixture ratio of Xe to the two component gas mixture consisting of Ne and Xe is 0.2 %, a spectral peak is observed at around a wavelength of 700 nm, i.e. in the visible region. By contrast, in Figs. 2b and 2c and Figs. 3a and 3b, in which the mixture ratios of Xe range from 2.0 % to 5.0%, two peaks appear in each of the emission spectra at around a wavelength of 820 nm and 880 nm respectively, i.e. in the near infrared region.

Based on these experimental results, Fig. 4 plots the relationship between spectral intensity and mixture ratio of Xe in the wavelength range between 820 nm to 880 nm. From Fig. 4 it is evident that the gas mixture influences the spectral intensity of near infrared rays. Specifically, the spectral intensity of near infrared rays is seen to be strongly dependent on the Xe content of the gas mixture.

Accordingly, the inventors have adopted a color PDP as follows.

Fig. 5 is a sectional view of the PDP device showing a first embodiment of the present invention.

In the PDP device shown in Fig. 5, a display panel 2, a front area of which is protected by a transparent protection plate 1, and a control portion 3 are provided to a front opened type casing 4.

The display panel 2 is made of a surface discharge panel having an AC (alternating current) type three-electrode structure, for example. As shown in Fig. 6, the display panel 2 comprises a front transparent substrate 21 formed of glass, and a back substrate 22 formed of glass. A plurality of address electrodes 23 aligned at a predetermined distance, stripe-shape partition walls 24 formed between the address electrodes 23 correspondingly, and fluorescent layers 25 covering respectively the address electrodes 23 and side surfaces of the partition walls 24 are formed on a surface area of the back substrate 22 opposing to the front transparent substrate 21.

The fluorescent layer 25 comprises a red fluorescent layer 25R, a green fluorescent layer 25G, and a blue fluorescent layer 25B, all emitting the lights when they are irradiated with ultraviolet rays, for example. The red fluorescent layer 25R, the green fluorescent layer 25G, and the blue fluorescent layer 25B are aligned in sequence to put respective partition walls 24 therebetween.

On a surface of the front transparent substrate 21 opposing to the back substrate 22 are formed display electrodes (called also as "sustain eleccrodes") 26 made of transparent conductive material and aligned adjacently in the direction intersecting with the address electrodes 23 so as to form a pair of electrodes respectively and metal bus electrodes 27 for supplementing their conductivity. In addition, a dielectric layer 28 for covering the display electrodes 26 and the bus electrodes 27 is formed. There are ITO (indium tin oxide), tin oxide (SnO_2), etc. as the transparent conductive material, while there are three-layered electrode made of Cr-Cu-Cr, etc. as the metal bus electrode 27. A surface of the dielectric layer 28 is covered with a protection layer 29 made of magnesium oxide.

The front transparent substrate 21 and the back substrate 22 are arranged to form a clearance (space) 30 between the protection layer 29 and the fluorescent layer 25, and their peripheries are hermetically sealed. The clearance 30 is filled with a gas at a low pressure. If being plasmanized, the gas may emit ultraviolet rays. For example, it is a gas mixture consisting of Xe and Ne.

On the front surface of the front transparent substrate 21 of the display panel 2 having such a structure, as shown in FIG.5, an electromagnetic wave shielding film 5 made of transparent conductive film and a first optical film 6 described later are formed in order. The electromagnetic wave shielding film 5 shields electromagnetic wave with a frequency ranging from 30 MHz to 1 GHz and an ordinary shielding film used in a common CRT is available.

A protection plate 1 formed in front of the display panel 2 is formed of transparent material such as acrylic resin or glass. A front surface of the protection plate 1 is covered with a second optical film 7 and a back surface of the protection plate 1 is covered with an infrared absorption film 8 and a third optical film 9. Material such as glass or resin has in nature a function for cutting off the wavelength of less than 400 nm.

The protection plate 1 is provided to not only protect a surface of the display panel 2 but also increase strength of the overall PDP device. In order to improve structural strength of the protection plate 1 and the PDP device much more, it is preferable that the protection plate 1 is formed to have a roundish concave shape against the viewer, as shown in FIG.7, otherwise four sides of the protection plate 1 are fitted into a frame member 1a, as shown in FIGS.8A and 8B.

The above first to third optical films 6, 7, 9 have a characteristic shown in FIG.9, for example. Therefore, they serve as the anti-reflection film in the range of visible ray wavelength of 400 to 700 nm, but serve as the reflection film because reflectance becomes high in the range of infrared ray wavelength of about 820 to 880 nm. As such film, for instance, as shown in FIG.5, there is a film which is formed by stacking a high refractive index film 10a made of either a single layer such as TiO_2, Ta_2O_5, ZrO_2 or a multilayer consisting of Pr_6O_{11} and TiO_2 and a low refractive index film 10b made of MgF_2, SiO_2, or the like.

The low refractive index film 10b is arranged closed to the display panel 2. The high refractive index film 10a and the low refractive index film 10b may be stacked in a single layer respectively, or else a plurality of high refractive index films 10a and low refractive index films 10b may be stacked in repeated and alternate layers.

Luminance average reflectance of less 0.48 is preferred in preventing reflection of visible rays. By way of example, the characteristic for reflection preventing function on a surface of the film is given in FIG.10.

The luminance average reflectance (Rv) is given by an equation (1). Where, in the equation (1), $y(\lambda)$ is color matching function in XYZ colorimetric system, S(y) is spectral distribution of standard illuminant used for color display, and $R(\lambda)$ is spectral reflectance factor (%).

$$Rv = \frac{\int_{380}^{780} S(\lambda)\bar{y}(\lambda)R(\lambda)d\lambda}{\int_{380}^{780} S(\lambda)\bar{y}(\lambda)d\lambda} \quad \cdots (1)$$

An infrared absorption film 8 is a film for absorbing at least near infrared rays, and is made of resin including organic compound dye such as anthraquinone system, phthalocyanine system, etc., or resin including dye such as organic compound of metal complex, for example. In the structure wherein the infrared absorption film 8 is stuck on a back surface of the protection plate made of acrylic resin, optical transmittance within 300 to 1200 nm is given in FIG.11, for example. The infrared absorption film 8 may be stuck on the front surface of the protection plate 1.

Since the spectral transmittance curve of the protection plate 1 in which the infrared absorption film 8 and the third optical film 9 are laminated is illustrated in FIG.12, for instance, emission spectra other than the visible ray region (400 to 700 nm) are hardly emitted in the forward direction of the PDP device.

With the above, in the first embodiment, since the PDP device is provided with the infrared absorption film 8 and the first to third optical films 6, 7, 9, no malfunction of the device operated by using infrared rays occurs. Besides, since reflection of visible rays in the display panel 2 can be prevented, the PDP device which is more superior in color display than the conventional device can be achieved.

In the PDP device shown in FIG.5, the first optical film 6 has been stuck on the front surface of the display panel 2, then the infrared absorption film 8 has been stuck on the back surface of the protection plate 1, and then the second and third optical films 7 and 9 are stuck on the front and back surfaces of the protection plate 1 respectively. However, all of the infrared absorption film 8 and the first to third optical films 6, 7, 9 are not always necessitated, and at least one of them may be used. In addition, any of the front surface of the display panel 2 and the front and back surfaces of the protection plate 1 may be selected as the surface to which the infrared absorption film 8 is stuck.

In the display panel in which the above films are provided, since luminance of the red fluorescent layer 25R and spectrum are overlapped and part of red luminance is cut off, luminous quantity of the red fluorescent layer 25R is preferred to be increased in advance so as to supplement the cut-off components. In particular, bright red fluorescent layer may be selected, or an area of the red fluorescent layer 25R may be formed wide rather than areas of blue and green fluorescent layers 25B, 25G.

In the meanwhile, a clearance (distance) is needed between the protection plate 1 and the front transparent substrate 21. This clearance must be ensured to relax static load and impact load carrying capacity or to reduce heat transfer from the display panel 2 to the protection plate 1, in addition to prevent Newton rings due to contact of the front transparent substrate 21 with the protection plate 1.

In the event that constituting materials for the protection plate 1 and the front transparent substrate 21 have different thermal expansion coefficient, it is not preferable that the display panel 2 and the protection plate 1 are arranged to have contact with each other since bowing of the protection plate 1 occurs owing to heat radiated from the display panel 2.

In the above discussion, although gas mixture consisting of Ne and Xe has been sealed in the display panel 2, gas mixture mainly consisting of Ne and He, gas mixture into which Ar gas, Xe gas, or the like is added, and the like may be sealed instead of the Ne and Xe gas mixture. Radiant quantity of the lights emitted from the PDP device due to these gas mixture other than the visible rays can be reduced by the above structure. For example, gas mixture of Ne and Xe, gas mixture of He and Xe, gas mixture of He, Ar and Xe, or gas mixture of Ne, Ar and Xe, and others may be used as such gas.

By adding Ar, Xe, etc. into the Ne and He base gas mixture, or by adjusting a mixture ratio of these gases, the optical filter characteristic to absorb or reflect selectively unwanted lights may be given to these gases.

For the purposes of example, to suppress emission of infrared rays from the color PDP device, such a structure may be employed in addition to the above film laminated structure that a mixture ratio of Xe to the gas mixture consisting of Ne and Xe which are sealed in the display panel 2 is set less than 2 %. That is to say, the content of Xe may be selected to such an extent that radiant quantity of near infrared rays can be reduced rather than the case where the mixture ratio of Xe is 2 %. It is desired that the mixture ratio of Xe is selected such that spectrum intensity of the near infrared rays is below the half of spectrum intensity of the visible ray wavelength, preferably less than 1/3 of spectrum intensity of the visible ray wavelength.

By the way, if the mixture ratio of Xe is below 2 %, luminescence color of Ne, i.e., the light having wavelength of around 700 nm becomes conspicuous, as shown in FIG.2A. As a result, it is likely that chromatic purity is deteriorated as the color PDP and that chromaticity of red, blue, and green primary colors is lowered.

Hence, by sticking an optical film, which has a characteristic to absorb or reflect the lights with the wavelength of more than 650 nm, on the protection plate 1 or the front transparent substrate 21, as shown in FIG.13, or by sticking a filter, which has a characteristic to absorb or reflect selectively the wavelength of around 700 nm, on the protection plate 1 or the front transparent substrate 21, as shown in FIG.14, reduction in chromaticity can be prevented. Unless the optical film is used, the protection plate 1 or the front transparent substrate 21 having a characteristic to absorb or reflect such wavelength may be used.

In order to reduce radiant quantity of the light having the wavelength of around 700 nm emitted from the PDP, transmittance of the lights having the wavelength of less than 650 nm is preferred to be set more than twice as high as transmittance of the lights having the wavelength of around 700 nm. For example, filters having wavelength vs

optical absorption characteristic shown in FIGS.15 to 18 may be employed.

As shown in FIGS.2B and 2C, even in the case where the mixture ratio of Xe is less than 2 %, since a small peak of spectrum intensity appears in the wavelength band of around 700 nm, an optical film to absorb or reflect the lights having the wavelength of more than 650 nm is desired to be adhered to the protection plate 1 or the front transparent substrate 21 to improve chromatic purity.

When the above various films are stuck to the protection plate 1 or the front transparent substrate 21, a laminate method is used. These films may be laminated on an electrode forming surface side of the front transparent substrate 21. Furthermore, for infrared absorption, electromagnetic wave shielding, visible ray transmittance, or infrared reflection, not only those being formed as a film previously but also those being formed by depositing or coating infrared absorption material, electromagnetic wave shielding material, visible ray transmitting material, or infrared reflection material on the surface of the protection plate 1 or the front transparent substrate 21 may be used. Besides, in place of these films, another films having such optical function may be formed by a film forming method such as evaporation, CVD, or sputtering.

Various dye for absorbing predetermined wavelengths may be applied to a surface of the protection plate 1 or the front transparent substrate 21, or the aboves may be used in combination. In this fashion, if a function for absorbing the lights other than visible rays is provided to the protection plate 1 or the front transparent substrate 21, lamination of the film can be omitted, as shown in FIG.19A. As a result, assembling steps required for the PDP device can be lightened. A relationship between optical transmittance and wavelength in such protection plate 1 or front transparent substrate 21 is illustrated in FIG.19B.

By adopting a method using steps of adding inorganic substance and organic substance to material of the plate or film, then melting the resultant structure at an appropriate temperature and in appropriate atmosphere, and then annealing the resultant structure, a plate or film for reflecting or absorbing the lights having the wavelength other than visible rays may be formed on the protection plate 1 or the front transparent substrate 21 or the above filters.

For the purposes of example, if the protection plate 1 is formed of acrylic resin in terms of extruding process, heating temperature at 150 to 170 °C, heating time for five to twenty minutes, applied pressure at 15 to 50 g/cm^2, and pressure applying time for ten to thirty minutes are selected. If organic compound dye such as anthraquinone system, or phthalocyanine system, or dye such as organic compound of metal complex is added to the acrylic material, for example, a near infrared absorption function may be provided to the protection plate 1. Such dye may be added to the dielectric layer 28 covering the display electrode pairs.

In the event that the film for reflecting or absorbing the lights having the wavelength other than visible rays is formed, it may be coated on the substrate by using already known thin film forming method like vacuum deposition method, high-frequency ion plating method, or magnetron sputtering method.

In addition, if the film for reflecting or absorbing the lights having the wavelength other than visible rays is formed on various films, powders such as inorganic substance and organic substance, dye or ion crystal may be pasted by being mixed or kneaded on the plate to form the film.

The absorption wavelength bandwidth and the reflection bandwidth of respective filters discussed above may be readily achieved by selecting and adjusting a thickness of the currently available filter, an amount of added material, and the like. Although the AC type color discharge panel has been described in the above embodiment, the present invention is not limited to this panel, but may be applied to a DC type color discharge panel, monochromatic AC type or DC type discharge panel similarly, for example.

With the above discussion, according to the present invention, since the flat display device is provided with means for reflecting or absorbing at least near infrared rays in wavelength bandwidth other than visible rays, malfunction of the devices using near infrared rays can be prevented.

In addition, since an optical film serving as an anti-reflection film with respect to visible ray wavelengths and serving as a reflection and absorption film with respect to near infrared wavelengths is used as means for reflecting or absorbing near infrared rays, visible rays can be emitted from the flat display device to the outside without reflection and absorption in the flat display device. As a result, degradation in luminous display brightness of the flat display device can be prevented. Scattering of the protection plate and panel (glass) can be also prevented.

Further, since the flat display device is provided with the electromagnetic wave shielding film, as well as means for reflecting or absorbing near infrared rays, harmful influence upon a human body can be suppressed.

Furthermore, since, in the flat display device, the protection plate consisting of glass, acrylic resin, or plastic is arranged in front of the substrates which define the discharge space, radiation of the light having shorter wavelength than visible rays can be suppressed and in addition the structure of the device can be reinforced. Since the protection plate is formed to have a convex shape, or the periphery of the protection plate is attached securely into the frame member, structural strength of the protection plate can be improved.

In summary, since xenon and neon are included in the gas discharge space in the flat display device such that xenon comprises less than 2 % of the total, the radiant quantity of the light emitted from the flat display device and having 800 nm to 1200 nm wavelength can be dramatically reduced. As a result, harmful influences upon other devices

operated by near infrared rays can be prevented or reduced.

Since the flat display device is provided with means for absorbing or reflecting light having wavelengths beyond 650 nm, the radiant quantity of light at about 700 nm can be reduced to thus suppress deterioration in chromatic purity and chromaticity of a color display.

If the transmittance of the light having the wavelength below 650 nm is set more than twice as high as transmittance of the light having the wavelength of 700 nm, optical intensity at the wavelength can be reduced to thus suppress deterioration in chromatic purity and chromaticity of a color display.

If the mixture ratio of the gas mixture is set such that spectral intensity of infrared rays is less than the half of the spectral intensity of visible rays in the gas discharge space of the flat display device, the potential influence of the flat display device upon other devices can be reduced.

Various modifications will become possible for those skilled in the art after receiving the teachings of the present disclosure without departing from the scope thereof.

Claims

1. A flat display device comprising a pair of substrates (21, 22) for defining a gas discharge space in which a gas used to generate discharge luminance is sealed, characterised by means (6 to 9) for absorbing or reflecting near infrared rays.

2. A flat display device according to claim 1, wherein said absorbing or reflecting means (6 to 9) is provided on a front substrate (21) of said pair of substrates (21, 22).

3. A flat display device according to claim 1 or 2, wherein said gas includes at least xenon and neon, the mixture ratio of xenon in said gas being less than 2%.

4. A flat display device according to claim 1, 2 or 3, wherein said gas is a gas mixture having a mixture ratio set such that the spectral intensity of near infrared rays emitted by the discharge is less than half the spectral intensity of visible rays.

5. A flat display device according to claim 1 or 2, wherein said gas includes at least xenon and neon, the mixture ratio of xenon in said gas being 2% or more.

6. A flat display device comprising a pair of substrates (21, 22) for defining a gas discharge space (30) in which a gas used to generate discharge luminance is sealed, characterised in that said gas includes at least xenon and neon, the mixture ratio of xenon in said gas being less than 2%.

7. A flat display device according to claim 6, wherein said mixture ratio of xenon is set such that the spectral intensity of near infrared rays emitted by the discharge is less than half of the spectral intensity of visible rays emitted by the discharge.

8. A flat display device comprising a pair of substrates (21, 22) for defining a gas discharge space (30) in which a gas mixture used to generate discharge luminance is sealed, characterised in that the mixture of gases in said gas mixture is such that the spectral intensity of near infrared rays emitted by the discharge is less than half of the spectral intensity of visible rays emitted by the discharge.

9. A flat display device according to claim 6, 7 or 8, and comprising means (6 to 9) for absorbing or reflecting near infrared rays.

10. A flat display device according to any one of the preceding claims and comprising a protection plate (1) arranged in front of said pair of substrates (21, 22).

11. A flat display device according to claim 10, when appended to any one of claims 1 to 5 and 9, wherein said absorbing or reflecting means (6 to 9) is provided on said protection plate (1).

12. A flat display device according to any one of claims 1 to 5, claim 10 when appended to any one of claims 1 to 5 and 9, or claim 11, wherein said absorbing or reflecting means (6 to 9) is formed of an optical film (6, 7, 9) which is transparent and anti-reflective with respect to visible wavelengths and reflective and absorptive with respect to

near infrared wavelengths.

13. A flat display device according to claim 12, wherein said optical film (6, 7, 9) is formed of a multilayer film comprising a high refractive index portion (10a) and a low refractive index portion (10b).

14. A flat display device according to claim 13, wherein said low refractive index portion is formed of MgF_2 or SiO_2, and said high refractive index portion has either a single layer structure consisting of a ZrO_2 film, a Ta_2O_5 film or a TiO_2 film, or a two-layered structure consisting of a Pr_6O_{11} film and a TiO_2 film.

15. A flat display device according to any one of claims 1 to 5, claim 10 when appended to any one of claims 1 to 5 and 9, or claim 11, wherein said absorbing or reflecting means (6 to 9) is formed of an infrared absorption film (8).

16. A flat display device according to claim 15, wherein said infrared absorption film (8) comprises a resin containing dye composed of organic compound.

17. A flat display device according to any of claims 2 to 4, claim 5 when appended to claim 2, claim 10 when appended to any one of claims 2 to 4 and 9, or claim 11, wherein said absorbing or reflecting means (6 to 9) comprises a deposition film provided on said front substrate (21) or said protection plate (1).

18. A flat display device according to any of claims 2 to 4, claim 5 when appended to claim 2, claim 10 when appended to any one of claims 2 to 4, or claim 11, wherein said absorbing or reflecting means (6 to 9) comprises a near infrared absorbent material comprising a dye.

19. A flat display device according to any of the preceding claims and comprising means (6 to 9) for absorbing or reflecting light having wavelength in excess of 650 nm.

20. A flat display device according to any of the preceding claims and comprising an electromagnetic wave shielding film (5).

21. A flat display device according to claim 20, wherein said electromagnetic wave shielding film (5) comprises a transparent conductive film.

22. A flat display device according to claim 10 or 11, or any one of claims 12 to 21 when appended to claim 10, wherein said protection plate (1) is arranged at a predetermined distance from said pair of substrates.

23. A flat display device according to claim 10 or 11, or any one of claims 12 to 21 when appended to claim 10, wherein said protection plate comprises glass, acrylic resin and/or plastics material.

24. A flat display device according to claim 10 or 11, or any one of claims 12 to 23 when appended to claim 10, wherein said protection plate (1) is secured in a frame.

25. A flat display device according to claim 10 or 11, or any one of claims 12 to 24 when appended to claim 10, wherein said protection plate (1) has a convex profile.

26. A flat display device according to any one of the preceding claims and comprising display electrodes (26, 27) between said pair of substrates (21, 22), said display electrodes (26, 27) being coated with a dielectric film (29) and a dye absorbent to near infrared light.

27. A flat display device according to any one of the preceding claims and comprising a plurality of fluorescent layers (25) with different luminescence colors provided in said gas discharge space.

28. A flat display device according to any one of the preceding claims, wherein the transmittance of light of a wavelength of less than 650 nm is at least twice as high as the transmittance of light of a wavelength of 700 nm.

FIG.1(Prior Art)

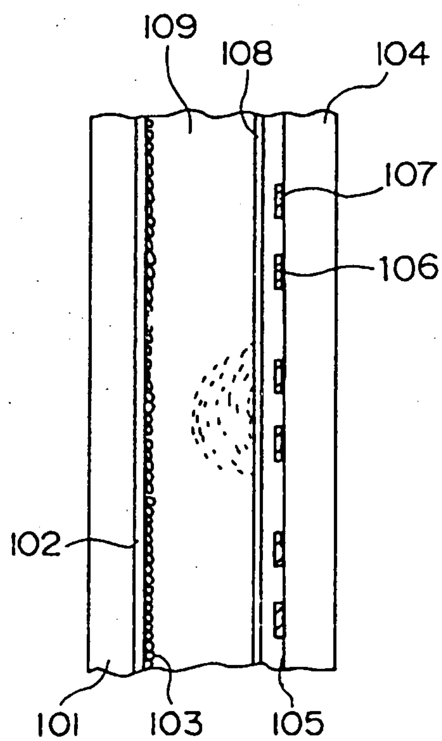


FIG.2A

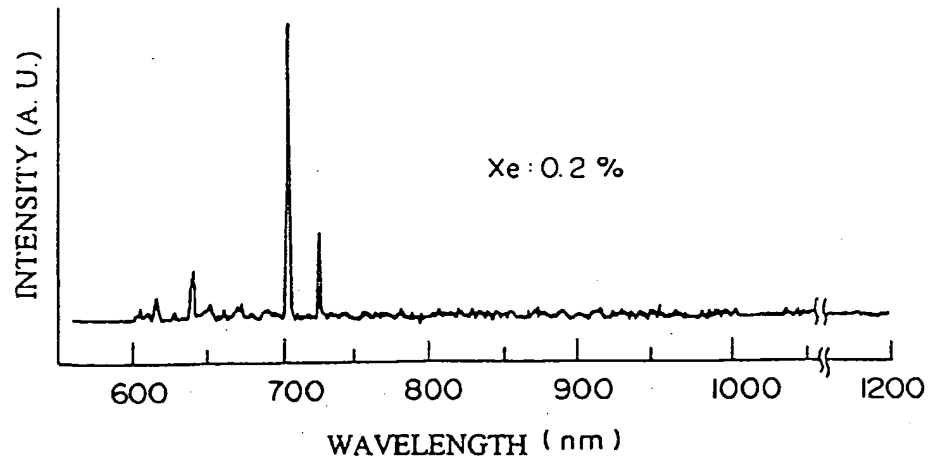


FIG.2B

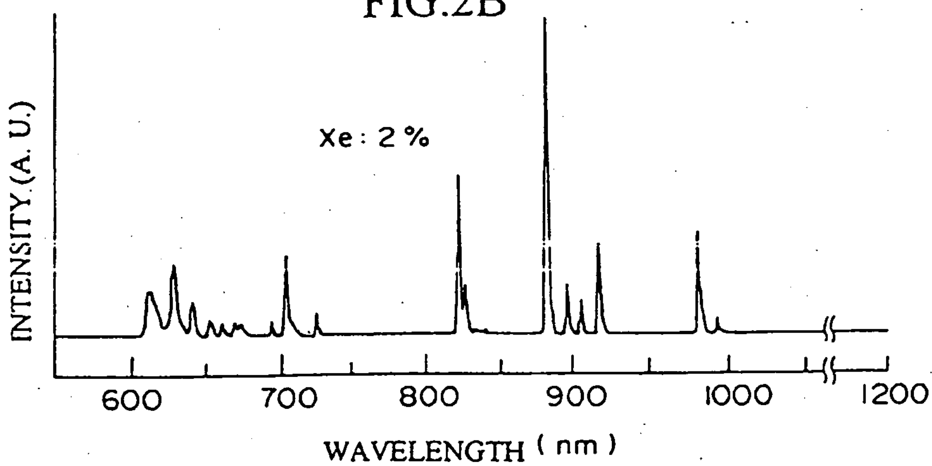


FIG.2C

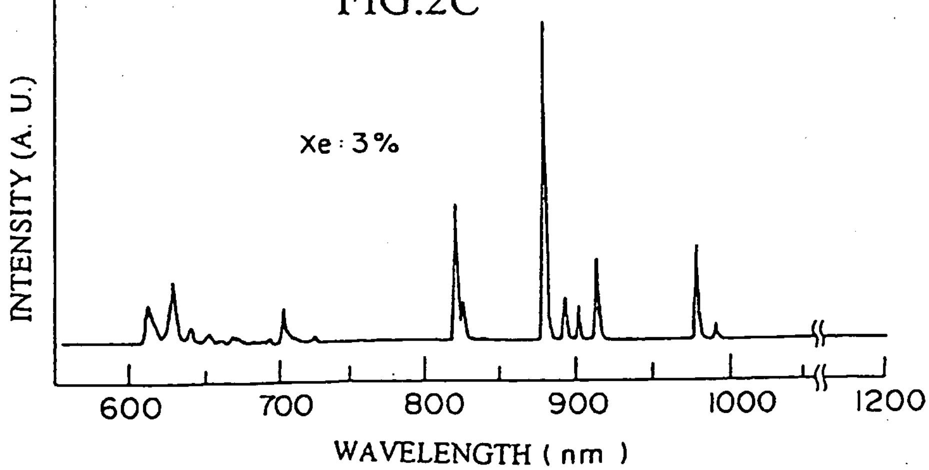


FIG.3A

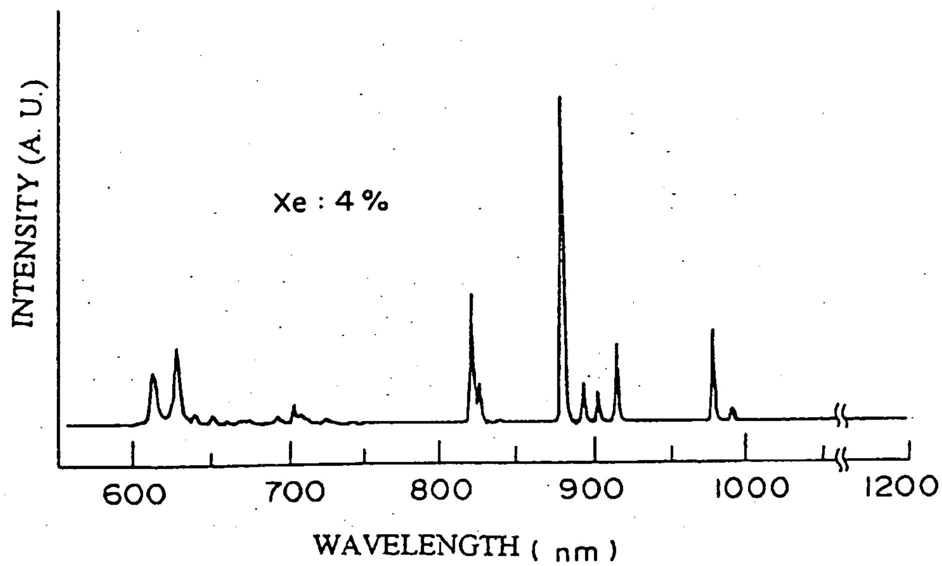

INTENSITY (A. U.)
Xe : 4 %
600
700
800
900
1000
1200
WAVELENGTH (nm)

FIG.3B

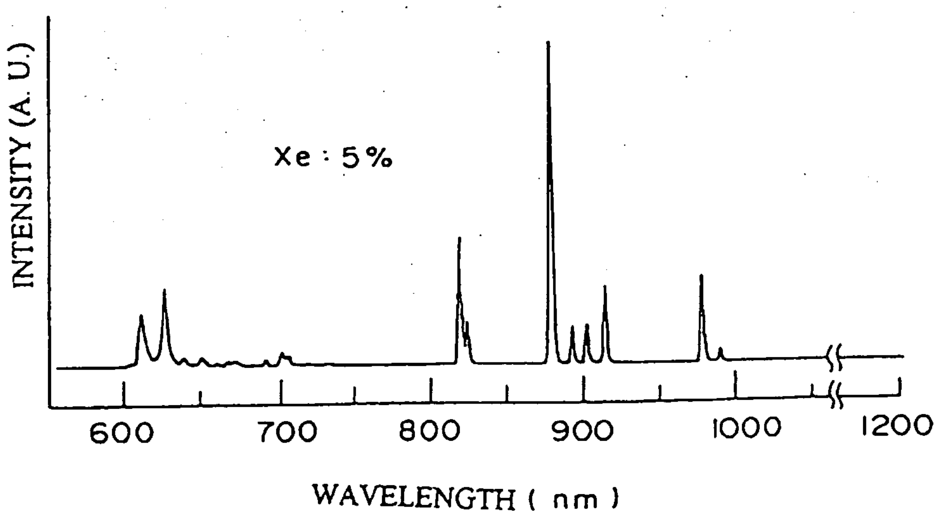

INTENSITY (A. U.)
Xe : 5 %
600
700
800
900
1000
1200
WAVELENGTH (nm)

FIG.4

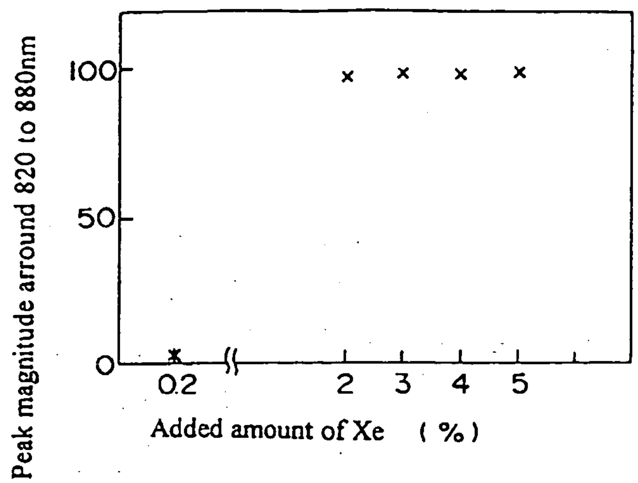
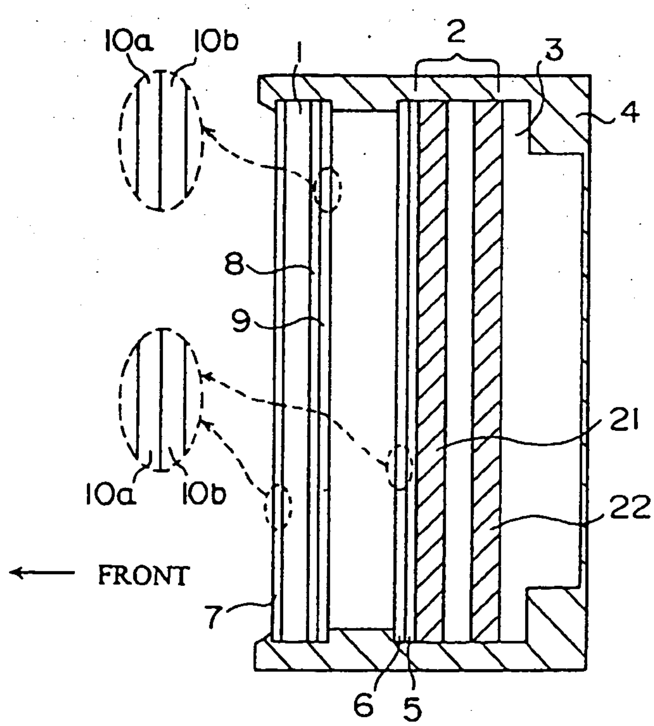

Peak magnitude arround 820 to 880nm
100
50
0
0.2
2
3
4
5
Added amount of Xe (%)

FIG.5


10a
10b
1
2
3
4
8
9
21
22
10a
10b
FRONT
7
6
5

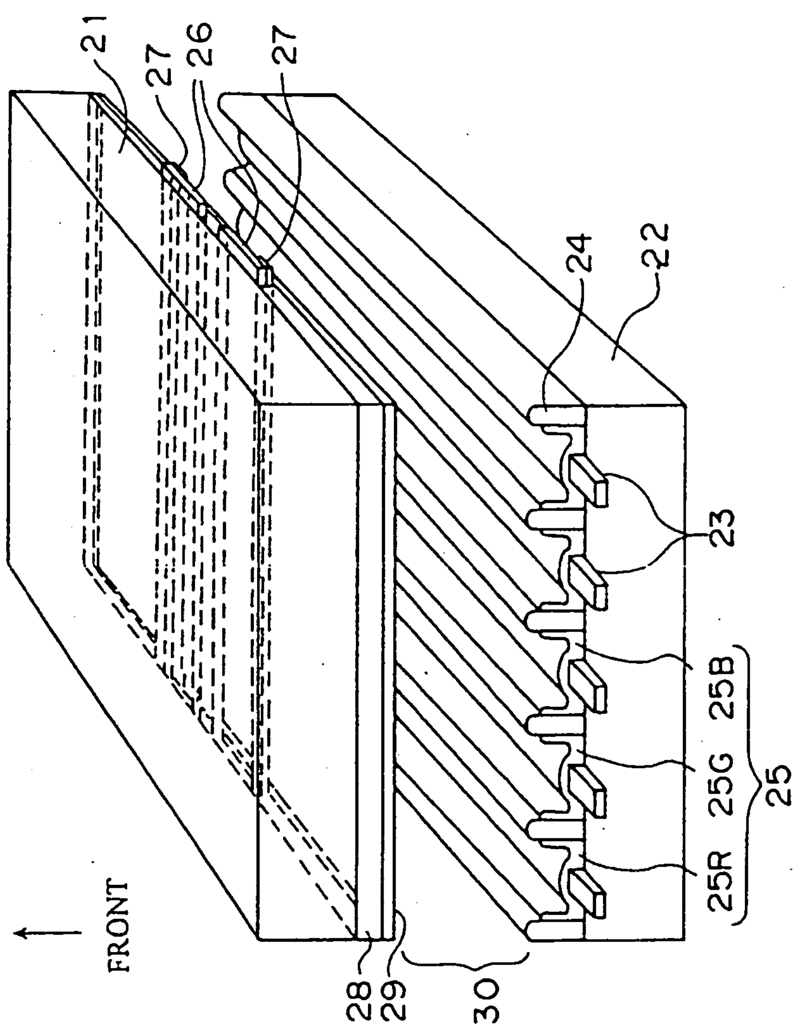


FIG.6

FIG.7

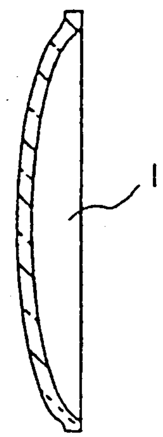


FIG.8A

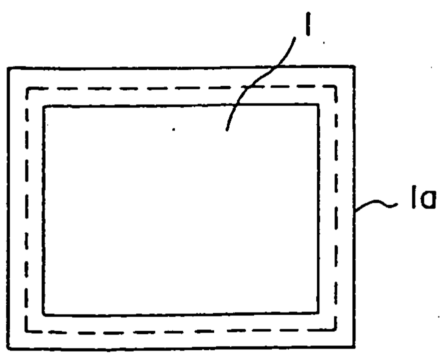


FIG.8B

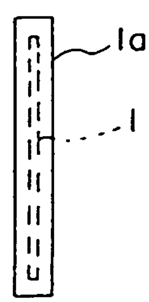


FIG.9

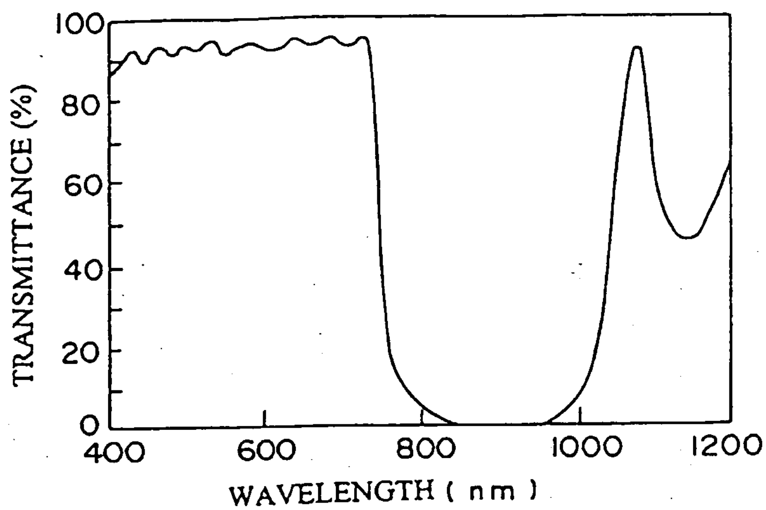

100
80
60
40
20
0
TRANSMITTANCE (%)
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.11

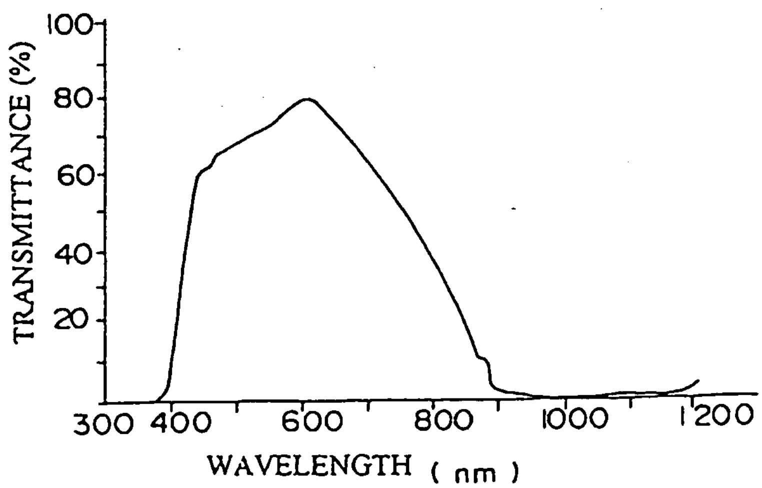

100
80
60
40
20
TRANSMITTANCE (%)
300
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.10

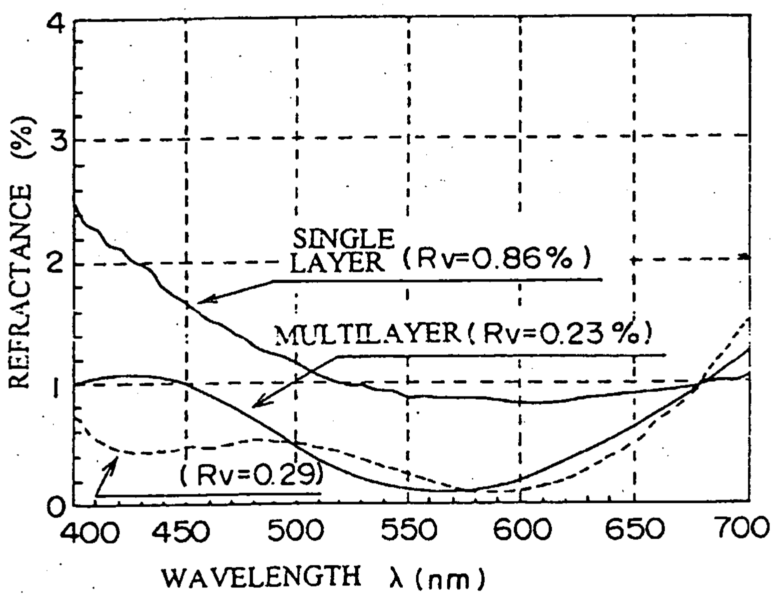

REFRACTANCE (%)
SINGLE LAYER (Rv=0.86%)
MULTILAYER (Rv=0.23%)
(Rv=0.29)
WAVELENGTH λ (nm)
0
1
2
3
4
400
450
500
550
600
650
700

FIG.12

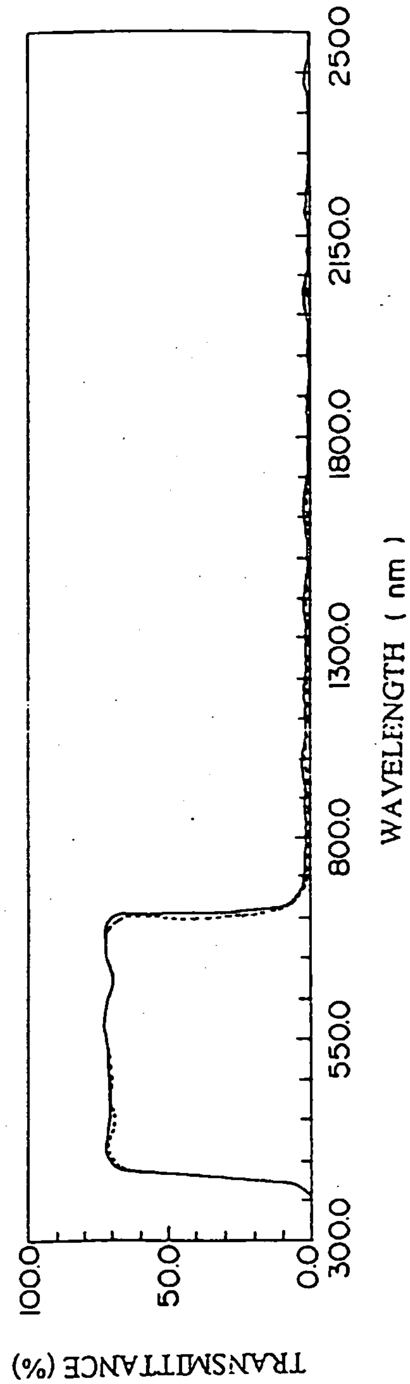

TRANSMITTANCE (%)
100.0
50.0
0.0
300.0
550.0
800.0
1300.0
1800.0
2150.0
2500.0
WAVELENGTH (nm)

FIG.13

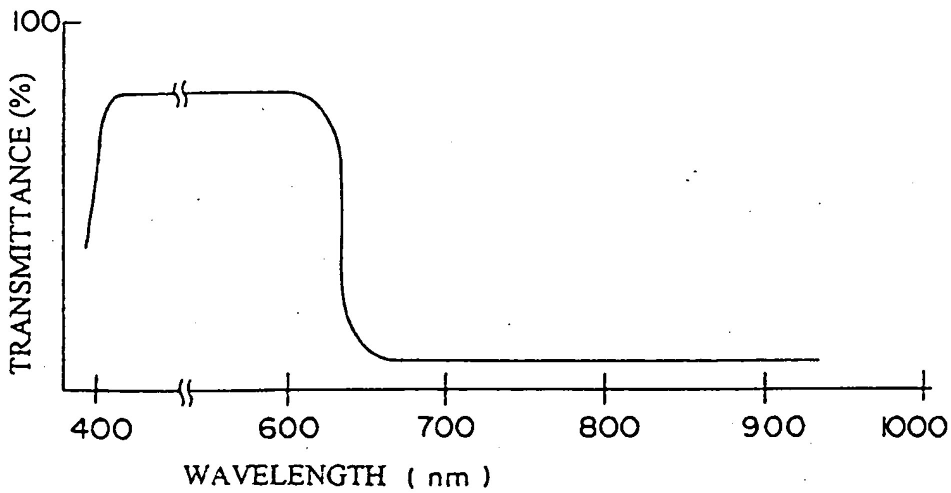

100
TRANSMITTANCE (%)
400
600
700
800
900
1000
WAVELENGTH (nm)

FIG.14

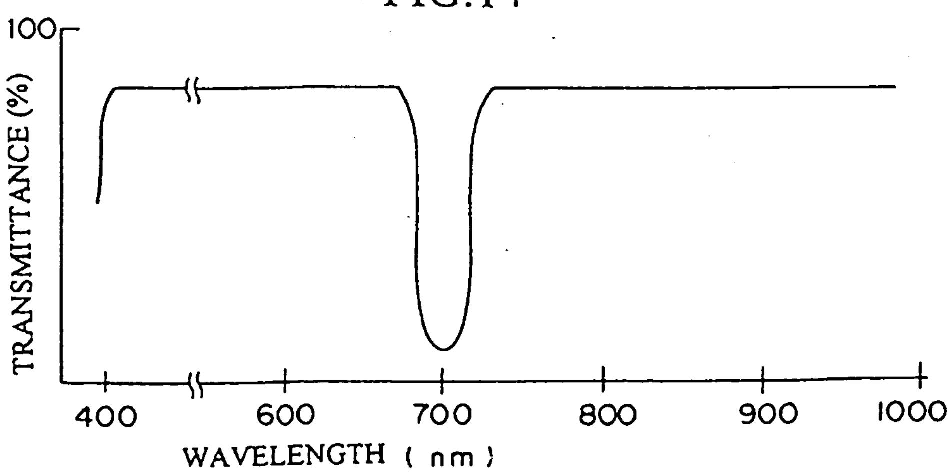

100
TRANSMITTANCE (%)
400
600
700
800
900
1000
WAVELENGTH (nm)

FIG.15

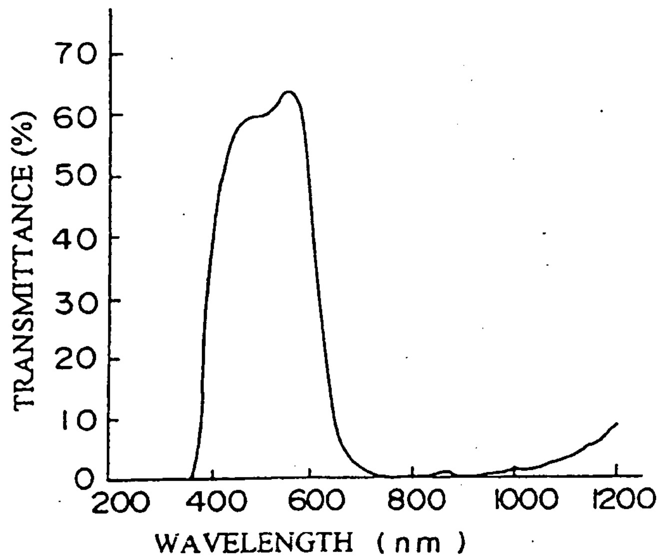

70
60
50
40
30
20
10
0
TRANSMITTANCE (%)
200
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.16

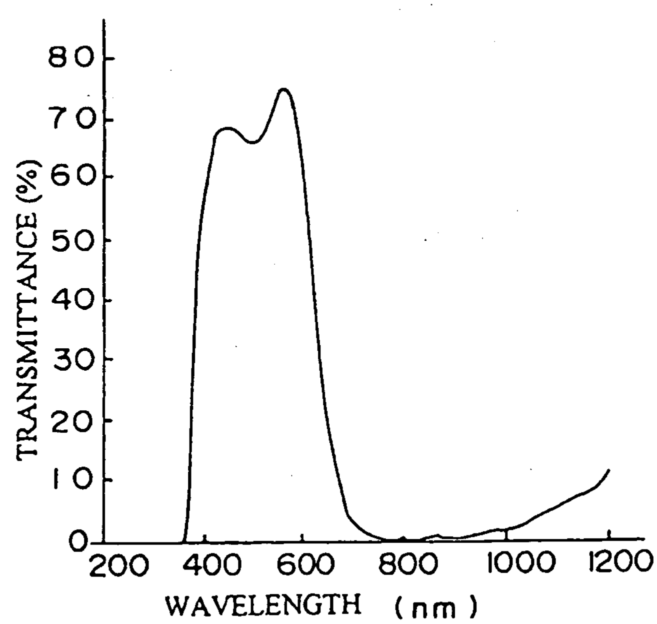

80
70
60
50
40
30
20
10
0
TRANSMITTANCE (%)
200
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.17

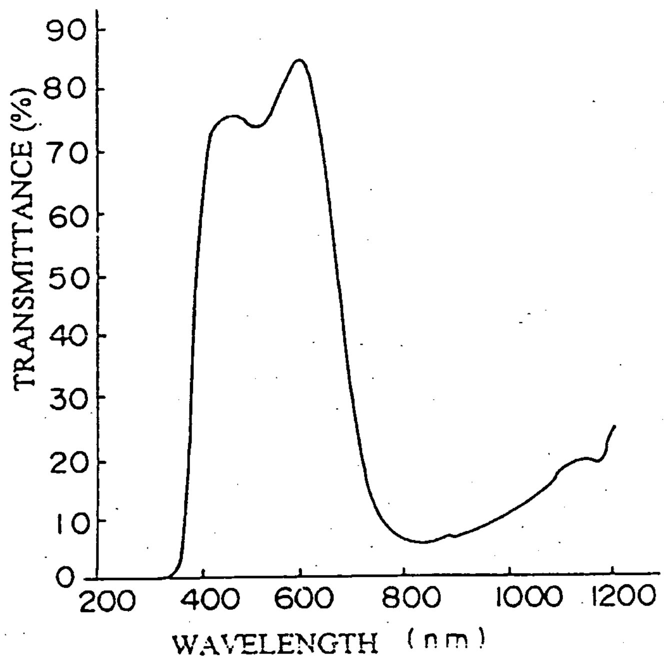

TRANSMITTANCE (%)
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.18

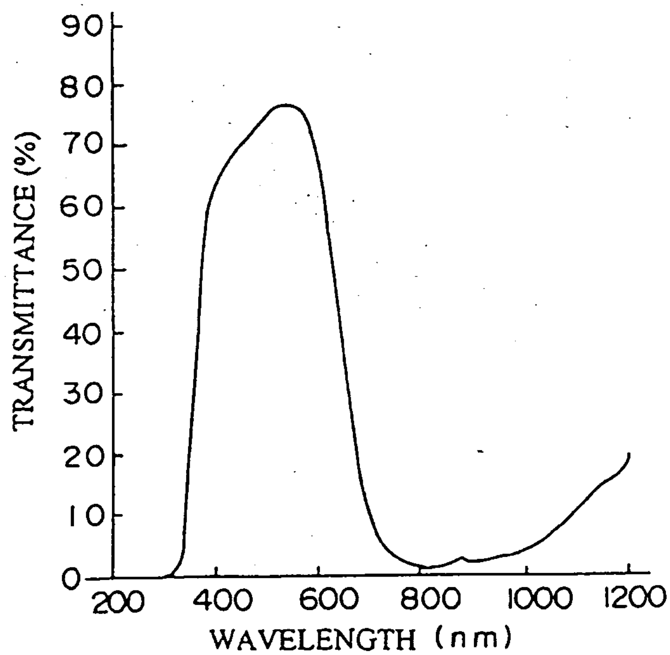

TRANSMITTANCE (%)
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
WAVELENGTH (nm)

FIG.19A

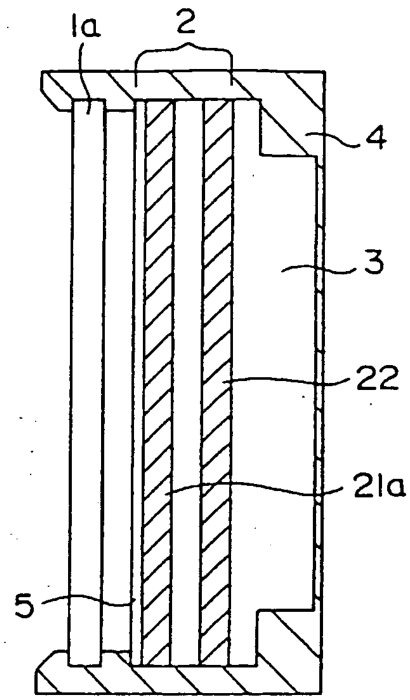
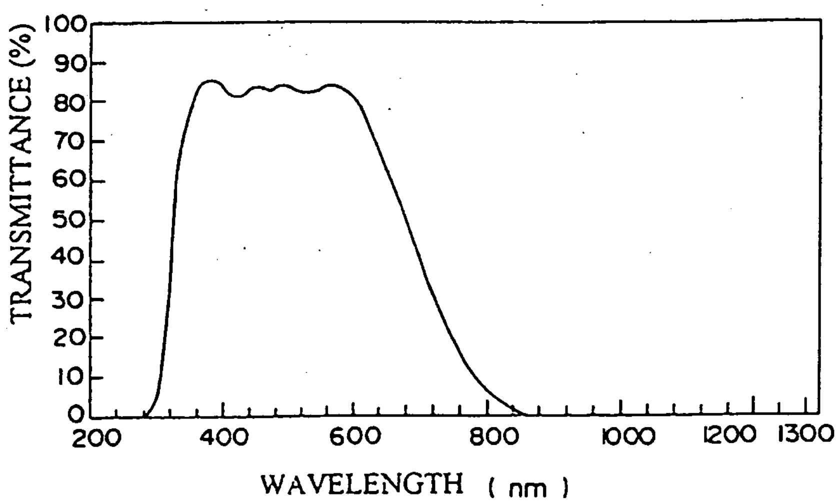


FIG.19B



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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 3907

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 584 (E-1018), 27 December 1990 & JP 02 256144 A (FURUKAWA ELECTRIC CO LTD:THE), 16 October 1990, * abstract *	1	H01J5/16 H01J29/89
A	WO 96 06453 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) 29 February 1996		
A	EP 0 074 440 A (HANLET JACQUES M) 23 March 1983 * claims 1,9 *	1,5	
E	EP 0 782 164 A (MITSUI TOATSU CHEMICALS ;YAMAMOTO CHEMICALS INC (JP)) 2 July 1997 * claims 1-9 *	1,15,16	
E	DATABASE WPI Week 9733 Derwent Publications Ltd., London, GB; AN 354398 XP002041346 & JP 09 145 919 (FUJITSU) , 6 June 1997 * abstract *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01J
E	& JP 09 145 919 A	1	
E	DATABASE WPI Week 9733 Derwent Publications Ltd., London, GB; AN 354397 XP002041347 & JP 09 145 918 (FUJITSU) , 6 June 1997 * abstract *	1	
E	& JP 09 145 918 A	1	
	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 September 1997	Van den Bulcke, E

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